5.14 Cumulative Impacts

This section includes discussions of past, current, and reasonably foreseeable future actions in the Hanford area. Current and future activities include preparation for and disposal of tank waste, CERCLA remediation projects, decontamination and decommissioning of the Hanford production reactors and other facilities, operation of a commercial LLW disposal site by U.S. Ecology, Inc., and operation of the Columbia Generating Station by Energy Northwest.

Potential cumulative impacts associated with implementing the various HSW EIS alternative groups are summarized in this section for storage, treatment, and disposal of the range of waste volumes evaluated. For most resource and potential impact areas, the combined effects from the alternative groups for the Hanford Only, Lower and Upper Bound volumes, or for the No Action Alternative for the Hanford Only and Lower Bound waste volume, when added to these other activities, are small.

The CEQ on assessment of cumulative impacts.

In 40 CFR 1508.7, the Council on Environmental Quality (CEQ) defines cumulative impact as:

"...the impact on the environment from the incremental impact of the action when added to other past, present, and reasonably future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time)."

In CEQ 1997, the CEQ states:

"The continuing challenge of cumulative effects analysis is to focus on important cumulative issues…."

5.14.1 Land Use

Consistent with past NEPA actions, land within the 200 Areas has already been committed for industrial-exclusive use, including waste disposal (HCP EIS) (DOE 1999). Radionuclides are present in the soil from past discharges, disposal actions, or tank leaks. Because of their chemical characteristics and very long half-lives (for example, cesium-135 with a half-life of 2.3 million years), some radionuclides are held in the soil indefinitely.

Waste previously disposed of in the solid waste disposal facilities currently occupies 130.5 ha (322 ac) of the Hanford Site. As discussed in Section 5.1, additions to the commitment of land area for waste disposal would range from about 19.2 ha (47 ac) for the Hanford Only waste volume as disposed of in any of the configurations of Alternative Groups D or E to 79.6 ha (197 ac) for the Upper Bound waste volume estimate as disposed of in Alternative Group B (see Section 5.1). Waste management activities through 2046 (Upper Bound waste volume) would be expected to require up to a total of 427 ha (1050 ac) for waste storage, treatment, and disposal facilities and for capping materials. Of this total, 210 ha (519 ac) would be permanently committed for disposal of wastes in Alternative Group B (largest requirements). This amount would represent about 4.2 percent of the 5000-ha (12,350-ac) within the area previously designated for long-term waste management activities in the HCP EIS (DOE 1999).

5.14.2 Air Quality

As discussed in Section 5.2, air quality standards at the Hanford Site boundary would not be approached or exceeded as a result of implementing any of the options described here or in combination with other reasonably foreseeable actions at the Hanford Site (see Section 5.2). This is due in large part to the current and projected:

- low density and intensity of pollutant emitting activities on the Hanford Site and in neighboring areas of south-central Washington
- relatively low population density in the region (minimizing the contribution of urban impacts on the region's air quality)
- substantial distances between the project activities and the Hanford Site boundary
- atmospheric dispersion conditions at Hanford that are generally favorable and meteorological conditions that could lead to a severe atmospheric stagnation event are of low-to-moderate frequency (and typically of short duration).

Quantification of cumulative non-radiological impacts for criteria pollutants was based on data presented in the TWRS EIS and is shown in Table 5.142 (DOE and Ecology 1996). The maximum impacts from activities evaluated in this HSW EIS are presented in Table 5.143 for comparison.

Table 5.142. Cumulative Air Quality Impacts for Criteria Pollutants

Sources	Maximum Average Concentration (g/m^3)			
	Particulate (PM-10)	Nitrogen Oxides (NO_X)	Sulfur Oxides (SO_X)	Carbon Monoxide (CO)
Hanford Site Baseline	3	3	19	3
Hanford Remedial Action	43	40	5	26
Environmental Restoration Disposal Facility	33	Negligible	Negligible	Negligible
Tank Waste Remediation System Alternative	98	2.2	27	2500
Total	177	45	51	2529
Standard 1	150 (24 hour)	100 (Annual)	365 (24 hour)	10,000 (8 hour)
Notes: 1 Washington State standards				

Table 5.143. Largest Criteria-Pollutant Impacts for HSW Operations Among the Alternative Groups and the No Action Alternative

Alternative	Hanford Only and Lower Bound Waste Volumes				Upper Bound Waste Volume			
	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2
Alternative Group A, μg/m^3	69	81	470	0.84	74	98	590	0.8
Alternative Group B, μg/m^3	71	130	800	1.0	90	180	110	1.1
Alternative Group C, μg/m^3	60	79	460	0.79	61	80	470	0.78
Alternative Group D, μg/m^3	61	84	500	0.91	62	84	500	0.98
Alternative Group E, μg/m^3	60	93	530	0.84	62	95	530	0.97
No Action Alternative, μg/m^3	57	86	460	0.93	Not applicable			

(a) Standards are: 24-Hour PM_{10} = 150 μg/m^3, 1-Hour SO_2 = 1,000 μg/m^3, 8-Hour CO = 10,000 μg/m^3.
Annual NO_2 = 100 μg/m^3

It should be noted that the values presented in Tables 5.142 and 5.143 are maximums that would occur at different times and locations and may not be additive.

5.14.3 Ecological, Cultural, Aesthetic, and Scenic Resources

Cumulative impacts as they pertain to ecological, cultural, aesthetic, and scenic resources in general on the Hanford Site can be found in the HCP EIS, which is incorporated by reference (DOE 1999). There, it was concluded that the potential for cumulative impacts to biological resources could best be evaluated by determining the amount of BRMaP Level III and Level IV resources that could be affected.

This EIS does not change any land use designated by the HCP EIS ROD (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping of the Central Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. The HCP EIS contains the distribution of BRMaP Levels II, III, and IV resources for the DOE Preferred Alternative, before the 24 Command Fire. BRMaP mitigation would have been required for those areas that were designated Level III or Level IV. Assuming that the pre-fire condition represents the edaphic potential of the burned areas, the HCP EIS identified 16,833 ha (41,595 ac) in Conservation (Mining) and 3,115 ha (7, 697 ac) in Industrial-Exclusive as BRMaP Level III resources, out of a site resource base of 66,744 ha (164,927 ac). These areas contain no BRMaP Level IV resources. In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

Field surveys conducted during 2002 for each of the areas in which any of the HSW EIS alternative groups might be implemented identified the near PUREX disposal facility site (up to 24.5 ha [60 ac]) as mature shrub-steppe habitat that could qualify under BRMaP Level III and require mitigation. Isolated element occurrences in Area C might also qualify as Level III or Level IV, but would need to be re-examined nearer the time of planned disturbance (see Section 5.5).

The activities described in this EIS would take place in areas that are, and will be for the foreseeable future, dedicated to industrial type uses. However, the presence of the Hanford Reach Monument with its relatively low-density use and the portions of the Hanford Site designated for preservation/conservation would result in large areas remaining in a natural state.

Surveys of areas to be used in implementing each of the alternative groups did not disclose the presence of cultural resources (see Section 5.7). However, changes to the viewshed of the Hanford 200 Areas would occur as a result of activities evaluated in this EIS as well as other programs at Hanford. As facilities are closed and barriers are placed on waste disposal facilities, the visual appearance of waste disposal facilities would likely become more similar to the to pre-Hanford Site condition. Future uses of the Central Plateau are likely to include structures and activities consistent with its designation for Industrial-Exclusive use in the HCP EIS (DOE 1999). However, most areas of the viewshed on the Hanford Site are expected to remain in a near natural state due to designation of approximately 80,000 ha (200,000 ac) of the site as a National Monument (65 FR 114) and of many other major areas of the site for preservation/conservation (DOE 1999).

5.14.4 Geologic Resources

Geologic resources consisting of sand, gravel, silt/loam, basalt would be required in construction of modified RCRA Subtitle C barriers for any of the alternative groups and for the Hanford barrier to cover immobilized low-activity waste (ILAW) as disposed of in the No Action Alternative. The quantities of these resource expected to be required were presented in Section 5.10. The resources would be obtained from Area C identified in the HCP EIS (DOE 1999) as Conservation (mining). In areal extent, the requirements would at most (Alternative Group B) amount to about 10 percent of Area C designated for borrow-pit materials.

This EIS does not change any land use designated by the HCP EIS ROD (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping of the 200 Area Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. Appendix D of the HCP EIS discussed using 36.1 million cubic meters (47.3 million cubic yards) of fine textured soils and developing a basalt source that could yield 15.3 million cubic meters (20 million cubic yards) of basalt riprap. A maximum of 90 ha (222 ac) of area C would be used for geologic resource development, out of the 44,183 ha (109,179 ac) reserved by the HCP EIS for Conservation (Mining). In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

5.14.5 Socioeconomics

If a number of the projects being considered for Hanford were undertaken simultaneously, the activity levels and the workers needed to support the activities could temporarily strain community infrastructure. The impact of any of the HSW alternative groups or the No Action Alternative would each be small (300 to 500 workers out of 15,000 workers at the Hanford Site, see Section 5.6). The current projected baseline for Hanford shows declining budgets and employment beginning in about 2012. If this baseline is maintained and other considerations remain equal, most existing components of community infrastructure would be adequate to accommodate population growth of about 2000 residents associated with any of the HSW alternative groups in the long run. However, between 2003 and 2007, a projected 7000 new residents are expected move into the area to support construction of the Hanford tank waste treatment plant. These new arrivals and any early arrival of the up to about 2000 new residents related to the Hanford solid waste program in the Tri-Cities area could challenge the capacities of the local real estate markets, the transportation network, and the primary and secondary education facilities.

In addition, other projects are expected to be underway at Hanford in the near term, such as operations at the Hazardous Materials Management and Emergency Response (HAMMER) facility, cleanup of several older reactors and other buildings, and actions to remediate the K Basins, the vadose zone, and the groundwater on the site. These additional projects could increase Hanford employment by a few hundred workers during the period 2003 to 2010 and, therefore, might also affect the socioeconomic context against which the effects of any LLW, MLLW, and TRU waste-related activity under the proposed action would need to be judged (see Section 5.6).

While the increases in workers (300 to 500) mentioned above would be in addition to the existing Hanford work force of about 15,000, that work force is anticipated to temporarily increase (from activities other than associated with HSW) and then to generally decline after about 2005 and to continue to decline throughout the period of analysis (see Figure 5.1). Overall employment may even decline at a faster rate than presently forecast depending on the success of accelerated site cleanup. However, the impact of implementing any of the HSW alternative groups would be a small addition to cumulative socioeconomic impacts.

5.14.6 Public Health

Although large amounts of various chemicals have been used during Hanford operations over the years, the breadth and depth of documented, quantitative information regarding these chemicals is very limited when compared to the amount of information available about radioactive materials. However, as shown in Section 5.11, hazards from releases of chemicals to the atmosphere have been calculated to be very small for all HSW alternative groups and would not be expected to add measurably to cumulative impacts regardless of their magnitude.

As was shown in Section, 4.5.3.2, Figure 4.19, a number of chemicals, principally from past liquid discharges to the ground, are found in the groundwater at Hanford. Again, there is only fragmentary data on the source quantities and transport to groundwater of these chemicals. In one case, however, it was estimated that the inventory of nitrate in groundwater beneath the 200 Areas exceeded 90,000 tonnes (100,000 tons) (ERDA 1975). The inventory of nitrate in HSW is on the order of 6.2 tonnes (6.8 tons), which, if taken as an indication of incremental impact of all chemicals in HSW, would suggest that those chemicals would not add substantially to the cumulative impacts of existing chemicals in groundwater.

Cumulative impacts for the atmospheric, surface water, and groundwater pathways, which could lead to potential radiological impacts on the public, are presented in the following subsections (also see Section 5.11).

5.14.6.1 Atmospheric Pathway

A summary of cumulative radiological impacts on public health due to radiological air emissions from past, current, and reasonably foreseeable future activities at Hanford is provided in Table 5.144. Examples of past activities include operation of the fuel fabrication plants, reactors, the PUREX Plant and other fuel processing facilities, the Plutonium Finishing Plant, and research facilities. Current activities include site cleanup, waste disposal, and tank-waste stabilization, and reasonably foreseeable future activities include continuation of site cleanup, waste disposal, and immobilization of both high-level waste and low-activity waste, and related activities.

Table 5.144. Cumulative Population Health Effects in the Hanford Environs from Atmospheric Pathways due to Hanford Activities[a]

Source of Impacts	Dose person-rem	Latent Cancer Fatalities[b]
Past Hanford Operations (DOE 1995)	100,000	60
Ongoing and Proposed Operations		
Hanford Operations (1997–2046) (Poston et al. 2001)[c]	15	0
Columbia Generating Station (30 yr) (DOE 1996a)	21	0
HSW EIS—Atmospheric Releases		
Alternative Groups A, C, D & E–Range[d]	0.15 – 0.24	0
Alternative Group B–Range[d]	0.19 – 0.29	0
No Action Alternative–Range[e]	0.10 – 0.12	0
Reasonably Foreseeable Operations		
Plutonium Finishing Plant Stabilization (DOE 1996b)	140[f]	0
K Basin Fuel Treatment and Storage (DOE 1996a)	120[f]	0
TWRS Phased Implementation Alternative (DOE and Ecology 1996)	400[f]	0
Cumulative Total	100,696.3[g]	60
Perspective		
Cumulative Natural Background Dose–100 yr, 1946-2046	12,000,000	7,200

(a) Assumes constant population of about 380,000.
(b) Six inferred LCFs per 10,000 person-rem Values less than 0.5 were rounded to zero.
(c) Assumed to continue at the 2000 population dose rate.
(d) Range based on Hanford Only Waste Volume and Upper Bound Waste Volume.
(e) Range based on Hanford Only Waste Volume and Lower Bound Waste Volume.
(f) Value based on previous NEPA analyses.
(g) For the solid waste program, this number includes only the value of 0.3 person-rem from Alternative Groups A, B, C, D, or E—Upper Bound waste volume activities.

The cumulative population dose since startup of Hanford operations was estimated to be 100,000 person-rem (DOE 1995). The number of inferred latent cancer fatalities (LCFs) since Hanford startup inferred from such a population dose would amount to about 60, essentially all of which would be attributed to dose received in the 1945 to 1952 time period.

For perspective, since startup of the Hanford Site, the population of interest (assuming an average population within 80 km [50 mi] of 380,000 and an individual dose of 0.3 rem/yr [(NCRP 1987]) would have received about 6 million person-rem from naturally occurring radiation sources (that is, natural background), from which 3600 LCFs could be inferred.

If the entire Hanford Sitewide contribution to population dose from all exposure pathways were to remain at calendar-year 2000 levels through the period ending in 2046 (Poston et al. 2001), the estimated collective population dose would be about 36 person-rem. No LCFs would be expected from such a population dose.

This estimated level was based on a 0.3 person-rem/yr population dose from DOE facilities at Hanford, and a 0.7 person-rem/yr population dose from Energy Northwest's Columbia Generating Station for 30 years of operation (DOE 1996b). The largest contribution from solid waste management alternative groups to the total population dose of 36 person-rem would be about 0.3 person-rem (see Section 5.11).

Depending on the options selected, vitrification of the Hanford tank wastes could contribute up to about 400 person-rem to the cumulative, collective population dose (DOE and Ecology 1996). The cumulative, collective population dose for the Plutonium Finishing Plant could increase to another 140 person-rem depending on the option ultimately selected (DOE 1996b). Similarly, remediation of K Basins could add another 120 person-rem depending on options selected (DOE 1996b). No other activities are foreseen that would add substantially to these doses, and the total dose from these activities through the period ending in 2046 would not be expected to result in any LCFs.

Again for perspective, the doses to the local population from naturally occurring radioactive sources would result in about an additional 6 million person-rem for the 50-year period ending in 2046, from which another 3600 LCFs would be inferred. Thus, over about 100 years from the start of the Hanford operations to the year 2046, about 7200 LCFs might have resulted from naturally occurring sources. To this number of LCFs resulting from natural sources would be the inference that Hanford operations might have added about 60 LCFs as a result of airborne releases of radioactive material mainly during the 1945 to 1952 time period.

5.14.6.2 Surface Water Pathway

Past impacts associated with the water pathway were principally associated with contamination of Columbia River water that was used as once-through coolant for the eight Hanford production reactors. Various elements present in the incoming water were made radioactive during their passage through one or more of these reactors.[a] In addition, some of the corrosion products that formed in the plants' piping were made radioactive and entered the water. Fuel element failures (slug ruptures) also exposed the fuel to cooling water and added contaminants to the water. On an average annual basis, the principal radionuclides contributing to potential dose were phosphorous-32, chromium-51, zinc-65, arsenic-76, and neptunium-239. Contamination also occurred as a result of adding water-conditioning agents, with hexavalent chromium as the principal contaminant.

An estimate of collective population dose to the nearest downstream users of the Columbia River (Richland, Pasco, and Kennewick, Washington) from 1944 to present would amount to about 3000 person-rem, most of which occurred before 1971 at which time the last reactor that used once-through cooling was shut down. This estimate was based on the dose to people who drank water supplied by municipal water plants and estimates of the populations for Richland (after startup of its water treatment plant in late 1963), Pasco, and Kennewick, and included a nominal amount of time for people who engaged in boating and swimming in the Columbia River.[b] From 1971 to present, the collective population dose was estimated to be less than 400 person-rem. From a collective dose of 3000 person-rem, two LCFs could be inferred. The collective population drinking water dose for 2001 from the surface water pathway was determined to be 0.0024 person-rem (Poston 2001). If that annual dose were to continue over 10,000 years, the total from all future Hanford activities might amount to 27 person-rem. The addition of radionuclides from the disposal of HSW over that period was less than or equal to 0.3 person-rem at the Tri-Cities. Neither the current projection of drinking water dose nor that projected from disposal of HSW would add substantially to the past cumulative population dose derived from the Columbia River of 3400 person-rem.

The presence of contaminants in surface water as a result of inflow of groundwater, and a discussion of the cumulative impacts of contaminants in the groundwater itself are included in the next subsection.

5.14.6.3 Groundwater Pathway

Cumulative groundwater impacts are examined in the context of existing sources of contamination in the soil, vadose zone, and groundwater. The following contaminants have been consistently detectable in soil on the Hanford Site: strontium-90, cesium-137, uranium -238, plutonium isotopes (238, 239, 240), and americium-241. Contaminants in the vadose zone include cobalt-60, strontium-90, technetium-99,

(a) A ninth reactor, N Reactor, did not use once-through cooling. Past discharges to nearby trenches is a source for seepage of some contaminants into the river.

(b) Before 1971, higher doses would have been experienced by those individuals making recreational use of the Columbia River, consuming food crops grown with irrigation water derived from the river, consuming fish and waterfowl inhabiting the river, and consuming seafood harvested from along the Washington and Oregon coast. Due to the number of pathways and uncertainties in numbers of individuals involved, this aspect has not been quantified on a collective basis for the 1944 to present time period. Estimates of maximum and average representative individual doses may be found in Farris et al. (1994). Doses from 1971 to present were estimated from the maximally exposed individual (MEI) doses taken from annual reports and, consequently, are substantially higher than would be expected for individuals with typical dietary habits (for example, the annual per capita dose for 1999 was reported as 0.0007 mrem, and the MEI dose was reported as 0.008 mrem, thus the MEI dose overestimates the per capita dose by a factor of about 10.)

cesium-137, europium isotopes (152, 154), uranium isotopes (234, 235, 238), and plutonium isotopes (239, 240). Contaminants in the vadose zone also include non-radioactive materials including metals, votatile organics, semivolatile organics, and inorganics (Poston et al. 2002).

Groundwater beneath the operational areas and in plumes leading from the Central Plateau to the Columbia River is contaminated with hazardous chemicals and radionuclides from past liquid waste disposal practices. The existing level of contamination in the groundwater would exceed Federal Drinking Water Standards if it were a source of drinking water as defined in the standards (Poston et al. 2002). Hazardous chemical contaminants that would exceed this benchmark include nitrate, carbon tetrachloride, trichloroethene, and chromium, and radiological contaminants that exceed the Standards include tritium, iodine-129, strontium-90, technetium-99, and uranium. Concentrations of these radionuclides and hazardous chemicals currently in groundwater are shown in Section 4.5.3.1, Figures 4.18 and 4.19, respectively.

Action alternatives analyzed in this EIS do not exceed the 4-mrem per year benchmark public drinking water dose (see Section 3.4.3). By the time the waste constituents from the action alternatives are predicted to reach groundwater (hundreds of years) the waste constituents would not superimpose on existing plumes and would not exceed the benchmark dose, because the existing groundwater contaminant plumes will have migrated out of the unconfined aquifer by then.

Radionuclides leached from wastes disposed of in HSW disposal facilities could eventually be transported through the vadose zone to groundwater. For this analysis, it was assumed that an individual drilled a well through the vadose zone to the groundwater and used the groundwater as a source of drinking water. As an indication of cumulative Hanford groundwater impacts, the annual dose to an individual drinking 2 liters of that water per day and taking into account all wastes intentionally or unintentionally disposed of on the Hanford Site since the beginning of operations and waste forecast to be disposed of through 2046 (Lower Bound waste volume)[a] was calculated for technetium-99 and uranium isotopes using the System Assessment Capability (SAC) (Kincaid et al. 2000) software and data. Technetium-99 and uranium were selected for analysis because they are representative of the more mobile contaminants evaluated elsewhere in this EIS.

A SAC analysis of hypothetical future impacts was conducted based on conservative assumptions (that is, loss of institutional controls and cessation of barrier maintenance). The SAC analysis of the initial assessment for 10,000 years completed for the HSW EIS was comprised of two simulations: a

(a) ILAW from treating tank waste was not included in the original SAC or initial assessment. Initially the SAC was tasked to address a 1000-year period; however, technetium-99 and iodine-129 would not release from the ILAW form to the water table within that time period. An approximation of the drinking water doses combining SAC and ILAW results for technetium-99 and uranium is shown as a function of time in Figures 5.14(1), 5.14(2), and 5.14(3). Melters and naval reactor compartments also were not included as sources of radioactive releases in the original SAC assessment. They, like ILAW, were assumed to not release any activity during the initial 1000-year, post-closure period. Both of these waste types are encased in substantial steel containment and contain substantially lower inventories of technetium-99 and uranium than ILAW; therefore, they would not contribute to groundwater contamination and were not simulated.

stochastic analysis[a] and a deterministic analysis.[b] First was the 25 realization stochastic analysis. Each realization represents a possible combination of the uncertain parameters. Using a cumulative performance measure, such as cumulative dose at a point of interest, a single realization can be identified as the median response for the stochastic problem. The second simulation conducted was a median-inputs case where each stochastic parameter is assigned its median value in a single or deterministic simulation. Results of the stochastic simulations with the median case highlighted are provided in Appendix L. The results for the median-inputs case are presented here and in Appendix L as representative of a best-estimate simulation. For additional information on the SAC calculation process, see Appendix L to this EIS and the initial assessment report (Bryce et al. 2002). The SAC is the next generation capability intended to update and improve the 1998 Composite Analysis completed by Kincaid et al. (1998). Using the dose predicted in the ILAW performance assessment (Mann et al. 2001) the influence of ILAW disposal has been added to that predicted in the initial assessment median-inputs case simulated with SAC. Thus, the cumulative impact shown below for selected points is achieved by superimposing the published ILAW impact on the simulated initial assessment results.

The cumulative impact for technetium-99 in all Hanford sources is provided in Figure 5.38. This is the annual dose resulting from a 2 L/d drinking water scenario for technetium-99 at a line of analysis approximately 1 km (0.6 mi) southeast of the 200 East Area.

This annual dose exhibits an initial peak prior to the year 2000 and a second peak of approximately 2 mrem/yr within 200 years. This second peak appears to be related to releases from past liquid discharge sites in the 200 East Area. Additional, but lower, peaks of approximately 0.3 mrem/yr appear in approximately years 4300 and 7500. Releases from HSW disposal facilities in the 200 West Area are responsible for the peak in approximately year 4300. Tank waste residuals releasing in the 200 East Area from a 1-percent residual volume and a salt cake waste are responsible for the last peak. The underlying long-term dose declines to 0.06 mrem/yr by 10,000 years post-closure. This dose is related to long-term releases from HSW and other miscellaneous waste, which, when combined, account for approximately 0.04 mrem/yr, and from ILAW, which accounts for approximately 0.02 mrem/yr.

Based on uncertainty in the groundwater conceptual model, the ILAW contribution to the cumulative result may be approximately four times larger or 0.08 mrem/yr. The resulting cumulative 2 L/d drinking water dose from technetium-99 would be approximately 0.12 mrem/yr at 10,000 years post-closure. Somewhat higher contributions than shown here from HSW and other sources, (that is, 0.04 mrem/yr) may also occur because of uncertainty in the groundwater conceptual model utilized in the SAC; however, groundwater model uncertainty as it relates to the HSW contributions is addressed in Section 5.3 and Appendix G. It should be noted that the ILAW release and associated dose impacts play a role in the last several thousand years only and do not substantially influence the peaks described above.

(b) Stochastic Analysis: Set of calculations performed using values randomly selected from a range of reasonable values for one or more parameters; in contrast, see deterministic analysis. In the HSW EIS, the median value was reported.

(c) Deterministic Analysis: A single calculation using only a single value for each of the model parameters. A deterministic system is governed by definite rules of system behavior leading to cause and effect relationships and predictability. Deterministic calculations do not account for uncertainty in the physical relationships or parameter values. See stochastic analysis.

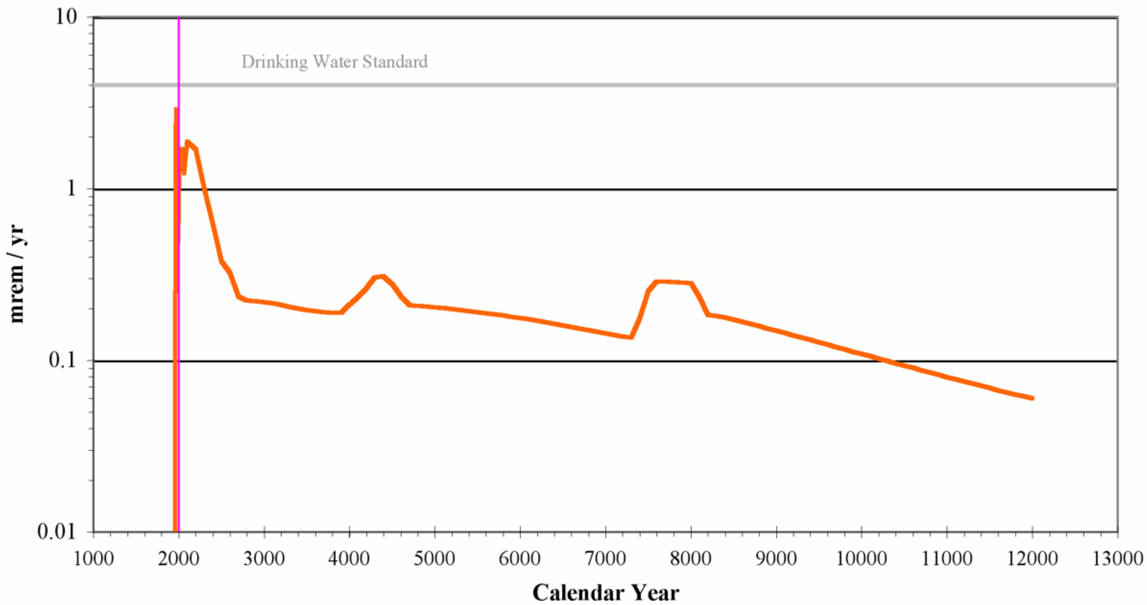

Figure 5.38. Annual Drinking Water Dose from Technetium-99 in Groundwater Southeast of the 200 East Area from All Hanford Sources

A plot of the cumulative drinking water dose for technetium-99 in all Hanford sources from Columbia River water at the City of Richland Pumping Station is provided in Figure 5.39. This location is down-river from all groundwater plumes of Hanford origin. While having a much more variable appearance caused by river discharge variability, the peaks seen in Figure 5.38 at the 200 East Area location are also present in Figure 5.39. However, the annual dose values are approximately five orders of magnitude lower than those predicted at the 200 East Area. The maximum estimated annual dose from technetium-99 over all 25 realizations of the stochastic analysis from the years 2000 through 9900 was determined to be less than 0.00008 mrem/yr, while the peak median dose was approximately 0.00004 mrem/yr.

Although groundwater simulations continued through the year 12,050 A.D. (10,000 years post closure; see Figure 5.38, the river simulations were terminated at the year 9900 A.D. due to the river model's software design constraints. Thus, river model forecasts are not available for the final 2000 years of the 10,000-year, post-closure period. However, as is apparent from the simulation results achieved, trends seen in the groundwater system near the Central Plateau appear somewhat later and at much reduced concentrations in the Columbia River at the City of Richland location.

Figure 5.40 shows the drinking water dose from uranium in Columbia River water at the City of Richland Pumping Station. The dose from Hanford-origin uranium also exhibits a temporal variability caused by variability in Columbia River discharge. However, the peaks are subdued and delayed for uranium, an element that is sorbed and migrates more slowly than groundwater and non-sorbed elements such as technetium. The maximum annual dose from uranium over all 25 realizations of the stochastic analysis from the year 2000 through the year 9900 was determined to be less than 0.002 mrem/yr, while the peak median dose was approximately 0.00005 mrem/yr.

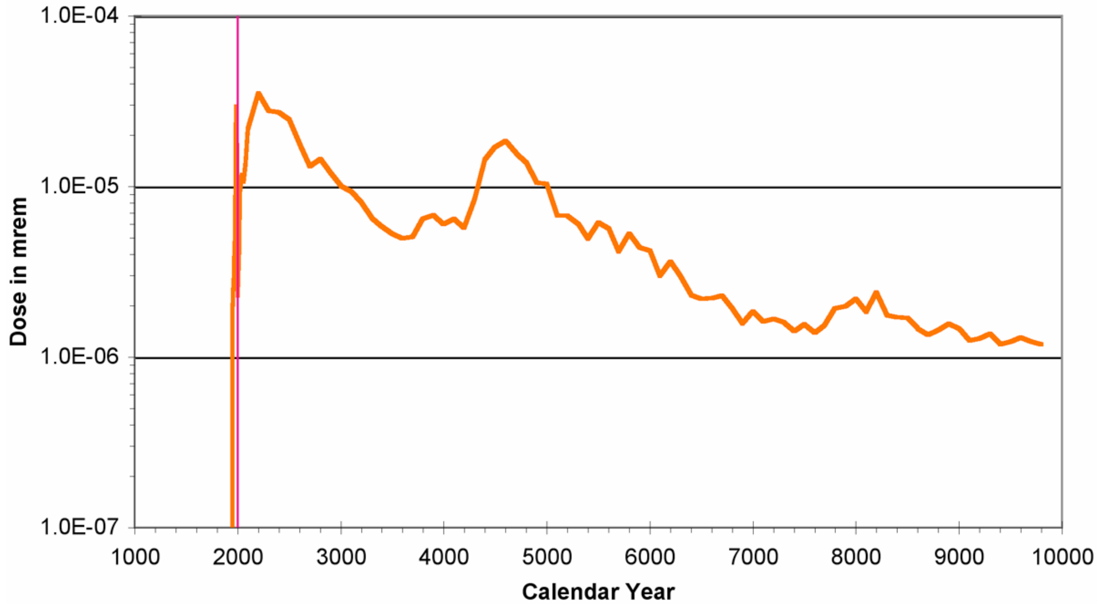

Figure 5.39. Annual Drinking Water Dose from Technetium-99 in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

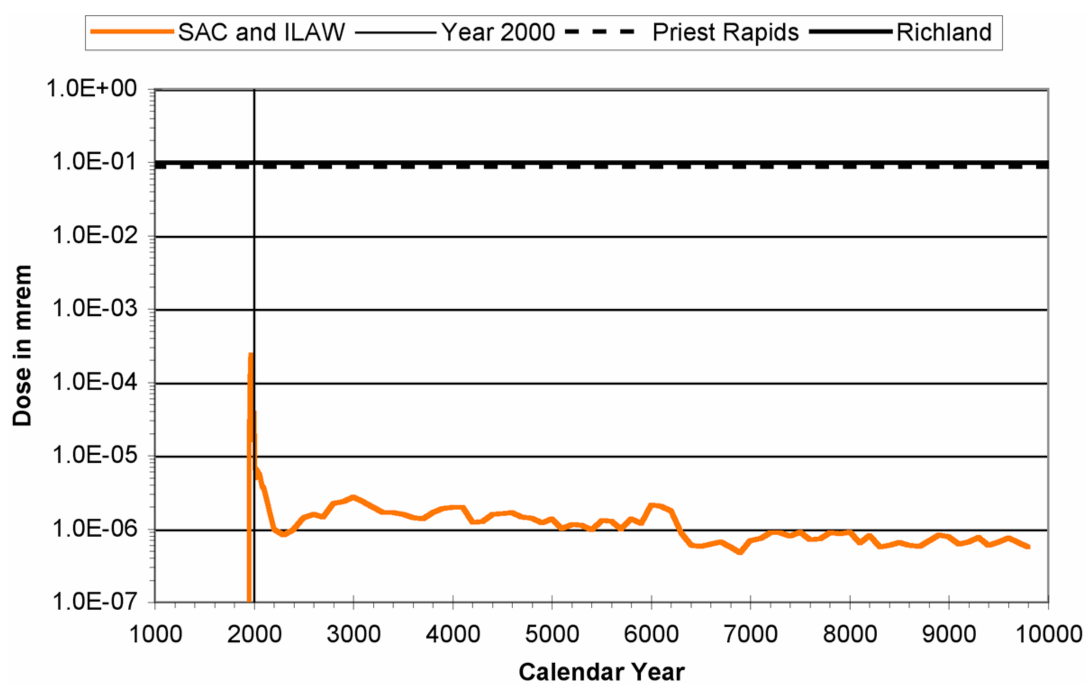

Figure 5.40. Annual Drinking Water Dose from Uranium in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

The annual drinking water dose at Priest Rapids, upstream of Hanford, and at the Richland Pumping Station, downstream of Hanford, are shown for uranium (Figure 5.40 based on a five-year average concentration of uranium at those locations (Poston et al. 2002). The technetium-99 measurements were not suitable for a similar presentation (concentrations at Priest Rapids were higher than at the City of Richland Pumping Station). In Figure 5.40, an estimate of the annual drinking water dose based on 5-year average isotopic uranium concentrations at Priest Rapids Dam (upstream of the Hanford Reach of the Columbia River) that are assumed to continue at those levels indefinitely is shown near the top of the figure (0.090 mrem) as a black dashed line. A similar dose estimate based on average uranium concentrations (0.099 mrem) at the City of Richland Pumping Station is shown as a solid black line.

The stochastic capability of SAC was employed to evaluate the relative role in overall release of different waste types including solid waste, past liquid discharges, tank wastes, and facilities including canyon buildings. The variability in the stochastic results is due to variability in the inventory, release, and transport of technetium-99 and uranium. The human dose calculations use fixed inputs. These results include all waste releases (for example, releases from cribs, ponds, solid waste, past tank leaks, future tank losses, tank residuals, unplanned releases) that were considered in the initial assessment performed by Bryce et al. (2002) and exclude the influence of the ILAW, melter, and naval waste forms and inventories.

In the SAC simulation, cumulative releases to groundwater from HSW, excluding ILAW disposed of in the Central Plateau, ranged from approximately 300 to 450 Ci for technetium-99 over the 12,050-year analysis period. This compares with releases to groundwater ranging from approximately 1500 to 2300 Ci of technetium-99 for all Hanford wastes except ILAW. Thus, the contribution to technetium-99 releases to groundwater from HSW, excluding ILAW, would amount to at most 20 percent of the cumulative release from all Hanford sources. The ILAW cumulative release of technetium-99 for the base case (Mann et al. 2001) used in this analysis was approximately 86 curies by the end of the 10,000-year, post-closure period. Thus, the contribution from HSW, including ILAW, for technetium-99 would amount to, at most, 25 percent of the cumulative release.

For uranium, releases from HSW, excluding ILAW, to groundwater are much lower in the SAC simulation. No realizations showed any release of uranium to groundwater from these wastes in the 200 East Area, and only 5 of 25 realizations show any release of uranium to groundwater from these wastes in the 200 West Area. Thus, in an average (or median) sense, deposits of HSW, excluding ILAW, would release no uranium to groundwater over the 10,000-year period of analysis. This compares with a median release of approximately 84 Ci and a range of releases to groundwater from the 25 realizations of between approximately 10 and 300 Ci of uranium for all Hanford wastes except ILAW. Of the five stochastic realizations exhibiting non-zero uranium release from HSW, excluding ILAW, in the 200 West Area, the cumulative release ranged from 0 to approximately 90 Ci. Hence, the contribution of HSW, excluding ILAW, to overall uranium release to groundwater lies between 0 and 90 Ci, but the majority of the realizations showed no release. As a consequence, the contribution of HSW, excluding ILAW, to uranium releases to groundwater would amount to between 0 and 30 percent of the cumulative release from all Hanford sources except ILAW, and likely would be zero. The majority of the technetium-99 and uranium releases from wastes other than ILAW were predicted to occur from liquid discharge sites (cribs, ponds, trenches) used in the past and from unplanned releases on the plateau and from off-plateau waste sites.

The SAC and HSW EIS approach (see Appendix G) simulations of uranium migration and fate that appear in this EIS differ in the relative roles of technetium-99 and uranium at times nearing the end of the 10,000-year, post-closure period analyzed because distribution coefficients for uranium in the two analyses differ. The SAC produces results where technetium-99 is the dominant radionuclide throughout the post-closure analysis period. However, the HSW EIS approach, which is applied to generate comparative analyses of the 33 alternative groups, predicts that uranium becomes dominant towards the end of the post-closure analysis. The distribution coefficients of the linear sorption isotherm model were assigned a value of 0.6 ml/g in the HSW EIS approach and a value of 3 ml/g for the median-value SAC simulation. The value used in the HSW EIS approach is a more conservative, lower value that causes more rapid migration at higher contaminant levels. The value used in the SAC is a median value, somewhat higher than the conservative value that causes slower migration and lower contaminant concentrations. As a result, the SAC assessment predicts that the median response will be dominated by technetium-99 with uranium making more of a contribution in the latter portion of the 10,000-year, post-closure period. The HSW EIS simulation of alternative groups shows uranium dominating in the last few thousand years because its mobility is greater in that model. The range of K_d applied for uranium in the stochastic SAC model includes the nominal value used in the HSW EIS simulation, and some realizations of the stochastic model exhibit the greater uranium mobility and contribution to dose seen in the HSW EIS results. However, the focus and purpose of the SAC simulation is to provide the central tendency or median simulation result.

Leaching of radionuclides from wastes disposed of in HSW disposal facilities and their transport through the vadose zone, to groundwater, and then to the Columbia River also would lead in the long term to small additional collective doses to downstream populations. The collective dose from HSW was calculated to be only about 0.14 person-rem for the total population of the cities of Richland, Kennewick, and Pasco, Washington, and 0.39 person-rem for a hypothetical population of a city the size of Portland, Oregon, that might draw water from the Columbia River in the vicinity of Portland. No LCFs would be inferred from such population doses.

In addition to technetium-99 and uranium, iodine-129 is another contaminant of interest. There is uncertainty with respect to the total inventory of iodine-129 in spent fuel irradiated at Hanford and the amount currently in groundwater. The inventory data and information assembled for the initial assessment (Bryce et al. 2002) revealed that approximately 75 curies of iodine-129 were generated during the irradiation of nuclear fuel in Hanford reactors. Most of the spent fuel was processed in facilities on the Central Plateau; however, some remains in spent fuel that is being moved to a central location on the Central Plateau prior to shipment to a national repository. Some of the iodine-129 inventory is conservatively counted in individual waste site inventories. When summed, the inventories disposed of at waste sites, released to the environment (for example, at cribs, into the atmosphere, into the Columbia River), and stored for future disposal at offsite locations exceed 75 curies and are approximately 100 curies.

Iodine is found in all three phases; solid, liquid, and gas, and has been identified in each of these waste types. Accordingly, some iodine-129 is found in solid waste, some in liquid discharges, and some in atmospheric releases. There is considerable uncertainty in the amount of iodine-129 that appears in each. In prior inventory compilations and the initial assessment, it was assumed that most of the iodine-129 resides in single-shell and double-shell tanks in the Central Plateau. Furthermore, it was assumed that all of the iodine-129 would be captured in secondary waste streams from waste separation and solidification processes, and that these wastes would be treated and the iodine disposed of, primarily, in solid waste disposal facilities. Of the 100 curies estimated at the site at the time of site closure in the initial assessment and this cumulative impact analysis, approximately 66 curies reside in solid waste, 19 curies may have been released to the atmosphere, 7 curies reside in spent fuel, 5.5 curies reside in commercial low-level radioactive waste disposal, 4 curies were discharged to cribs and trenches, and 2 curies are associated with the past leaks, estimated future losses, and residuals of tanks. None of the 66 curies of iodine-129 associated with solid waste in the cumulative assessment is assigned to ILAW because the early assumption was that iodine was too volatile to remain in the solidified low-activity tank waste.

As a result of recent estimates of iodine retention in immobilized tank waste, about 22 curies of the iodine-129 in the tank waste was assumed, for impact modeling purposes in this EIS, to be disposed of as part of the ILAW waste form. The model assumes an additional 5 curies is contained in the solid waste to be disposed of (see Appendix B, Table B.19). Thus the groundwater modeling performed for the actions in this EIS assumes a total source term of 27 curies of iodine-129 in the combined ILAW and solid wastes.

A bounding case for cumulative impacts would occur if releases from HSW EIS curies were released exactly in phase, in space and in time, with the assumed "cumulative impact" curies. If such exact phasing occurred, it would be expected that groundwater concentrations would be three to four times those reported for the HSW EIS alternative groups. However, due to the low-release characteristics of the ILAW waste form, the likelihood that a substantial portion of the cumulative impacts inventory of iodine-129 would be disposed in a cement waste form, geographic distribution, and variations in lining and capping techniques, it would be unlikely that such exact phasing would occur.

5.14.6.4 Transportation

Transportation impacts associated with transporting radioactive wastes and materials including that to and from the Hanford Site have been addressed in other NEPA documents. Table 5.143, based on DOE 2002 and this EIS, provides cumulative impact information from those analyses and analyses preformed for the HSW EIS.

In addition, this EIS presents a discussion of transportation of wastes that are within the scope of this HSW EIS in the States of Oregon and Washington (see Section 5.8).

The information in Table 5.145 indicates that the cumulative transportation impacts associated with any of the HSW EIS alternative groups are small relative to transport of radioactive material in general. For perspective, it may be noted that about 4.4 million traffic fatalities from all causes would be expected nationwide during the period 1943 to 2047 (DOE 2002a).

Table 5.145. Cumulative Transportation Impacts

Category	Workers LCFs[a]	General Population, LCFs	Traffic Fatalities
Representative Past and Reasonably Foreseeable Actions (Excluding HSW) Involving Transport of Radioactive Materials			
Historical DOE Shipments	0 (0.20)	0 (0.14)	Not Listed[b]
Sodium-Bonded Spent Nuclear Fuel	0 (<0.001)	0 (<0.001)	0 (<0.001)
Surplus Plutonium Disposition	0 (0.036)	0 (0.040)	0 (0.053)
Waste Management PEIS	10	12	36
Waste Isolation Pilot Plant	0 (0.47)	4 (3.5)	5
Cruiser and Submarine Reactor Plant Disposal	0 (0.003)	0 (0.003)	0 (0.0095)
Spent Nuclear Fuel and High-Level Waste – Oregon & Washington	0 (<0.055)	0 (<0.021)	0 (0.049)
General Transport of Radio-pharmaceuticals, Commercial LLW, etc.	198	174	22
Transport of Hanford Solid Wastes			
Alternative Groups A, C, D, and E - Onsite and Treatment at ORR	0 (0.45)	0 (0.15)	1 (0.52)
Alternative Group B - Onsite and Nearby Treatment	0 (0.068)	0 (0.055)	0 (0.49)
No Action Alternative - Onsite	0 (0.075)	0 (0.047)	0 (0.055)
Incoming Offsite Shipments, WA and OR impacts (Upper Bound Volume)	0 (0.21)	0 (0.13)	0 (0.078)
Hanford TRU Waste Shipments to WIPP			
Alternative Groups A – E	0 (0.088)	1 (0.95)	2 (1.6)
No Action Alternative	0 (0.061)	1 (0.51)	1 (0.87)

(a) Assumes 6 latent cancer fatalities (LCFs) per 10,000 person-rem.
(b) The low worker and population doses suggest low mileage for which no traffic fatalities would be expected.

5.14.7 Worker Health and Safety

The cumulative Hanford worker dose, since the startup of activities at Hanford, is about 90,000 person-rem (DOE 1995), to which would be added approximately 1000 person-rem from spent fuel management (DOE 1996b), 8200 person-rem from tank waste remediation (DOE and Ecology 1996), 730 person-rem for Plutonium Finishing Plant stabilization (DOE 1996a), and 765 to 873 person-rem through the year 2046 from management of Hanford solid waste, ILAW, and WTP melters (Hanford Only waste volume for Alternative Group A to either the Hanford Only or Lower Bound volume for the No Action Alternative, [see Section 5.11]). Thus, for about 100 years of Hanford operations, approximately 40 LCFs would be inferred among workers, none of which would be attributable to HSW program activities. Because of DOE restrictions on worker dose and rigorous application of the ALARA principle, the cumulative collective worker dose associated with all future Hanford Site restoration activities would not be expected to add substantially to the collective worker dose to date.